The Golden Hour

Scene 2: CT Scan

Lesson 2: How does a CT scan help diagnose TBI?

I. Overview
To understand the functional consequences of a traumatic brain injury, students need to be able to explain the close relationship between brain anatomy and physiology. In this lesson, students learn about different areas of the brain and the functions with which they are associated. Through readings and a segment of The Golden Hour game, they examine computed tomography (CT) scans and identify the structural changes to the brain after TBI and determine the injury type. After identifying the loci of injury, and using their understanding of brain structures and functions, they predict the type of impairment or disorder that might be caused by the brain injury. Students discuss the use of CT scan technologies for intervention to a traumatic brain injury and how quick identification of the location and the extent of the injury are critical for the golden hour.

II. Standards

National Science Education Standards
Content Standard F: Personal and Community Health

- Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability or death may be present. Humans have a variety of mechanisms—sensory, motor, emotional, social, and technological—that can reduce and modify hazards. (9–12 F: 1/1)
- The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be prevented, controlled or cured. Some diseases, such as cancer result from specific body dysfunctions and cannot be transmitted. (9–12 F: 1/2)
- Personal choice concerning fitness and health involves multiple factors. Personal goals, peer and social pressures, ethnic and religious beliefs, and understanding of biological consequences can all influence decisions about health practices. (9–12 F: 1/3)
- Families serve basic health needs, especially for young children. Regardless of the family structure, individuals have families that involve a variety of physical, mental, and social relationships that influence the maintenance and improvement of health. (9–12 F: 1/6)

Benchmarks for Science Literacy
The Human Organism: Mental Health
- Biological abnormalities, such as brain injuries or chemical imbalances, can cause or increase susceptibility to psychological disturbances. (6F/H2)

The Human Organism: Physical Health
- New medical techniques, efficient health care delivery systems, improved diet and sanitation, and a fuller understanding of the nature of health and disease give today's human beings a better chance of staying healthy than their ancestors had. (6E/H3a*)

III. Learning Objectives

<table>
<thead>
<tr>
<th>Learning Goals</th>
<th>Assessment Criteria</th>
<th>Location in Lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain the diagnostic role of CT scans.</td>
<td>Students are able to explain the use of computed tomography as a diagnostic tool and how it is used to identify traumatic brain injuries.</td>
<td>Introduced in Activity 1 and explained throughout lesson</td>
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<tr>
<td>Identify certain structures and lobes of the brain and their functions.</td>
<td>Students identify the structures and lobes of the brain and their function on a normal CT scan in The Golden Hour game.</td>
<td>Activity 1</td>
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<tr>
<td>Compare a normal CT scan with a CT scan of a brain-damaged patient and explain the structural changes.</td>
<td>Students are able to make comparisons between normal and injured CT scans to identify irregularities in an injured brain.</td>
<td>Activities 1 &amp; 2</td>
</tr>
<tr>
<td>Identify the different types and the loci of brain injury on CT scans.</td>
<td>Using a variety of CT scans, students examine various types of injuries that result from TBI and practice identifying the types and loci of damage.</td>
<td>Activity 2</td>
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<tr>
<td>Interpret CT scans and explain the potential functional outcomes of the TBI for the patient.</td>
<td>Students see various types of traumatic brain injuries and they practice interpreting the functional outcomes of various types of injury by looking at the location of damage as shown in the CT scans.</td>
<td>Activity 2</td>
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IV. Adaptations/Accommodations

Parts of the lesson require that the students have access to computers in order to play a computer game. If access to computers is limited, 2–4 students can be assigned to each computer.

Safety

There are no additional safety concerns associated with this lesson.
V. Timeframe for lesson

Opening of Lesson
- Discussion to review previous lesson and introduce current lesson – 15 minutes

Main Part of Lesson
- Activity 1: How to read a CT scan – 25 minutes
- Activity 2: How to read an abnormal CT scan – 45 minutes

Conclusion of Lesson
- Class discussion about CT scans – 5 minutes

VI. Advance prep and materials

Activity 1: How to read a CT scan

Materials:
- Student sheet “How to Read a CT Scan”: GH_L2_StudentSheet_HowToReadCTscan
- Student sheet “CT Report”: GH_L2_StudentSheet_CTreport
- Computers (one computer for every 1-2 students)
- Printer (optional) for printing student work

Preparation:
- Make copies of “How to Read a CT Scan” (1 per every 1-2 students)
- Make copies of “CT Report” (1 per student)
- There are two ways to prepare the computers for students:
  - Option 1: Make certain all computers will have online access while students play the game. Open The Golden Hour game through the Project NEURON website (neuron.illinois.edu).
  - Option 2: Download The Golden Hour game from the Project NEURON website onto each computer prior to class. An internet connection will not be necessary to play the game once downloaded onto the machine.
- Conduct a trial run of Scene 2: CT Scan of The Golden Hour game on a computer before beginning the lesson to make sure it can be accessed and is running smoothly on the computers. Prepare all the computers so students can quickly and easily begin the game.

Activity 2: How to read an abnormal CT scan

Materials:
- Student sheet “How to Read an Abnormal CT Scan”: GH_L2_StudentSheet_HowToReadAnAbnormalCTscan
- Student sheet “TBI Case Puzzle”: GH_L2_StudentSheet_TBICasePuzzle
For teacher reference: GH_L2_StudentSheet_TBICasePuzzle_ANSWERS
Computers connected to the internet (1 computer for 1–3 people)
Printer (optional) for printing student work

Preparation:
- Make copies of “How to Read an Abnormal CT Scan” and “TBI Case Puzzle” to hand out to each student (1 per every 1-2 students)
- Conduct a trial run of the CT Scan Assessment (Scene 2.5) of The Golden Hour game on a computer before beginning the lesson to make sure it can be accessed and is running smoothly on the computers.

VII. Resources and references

Teacher resources
Resources for additional information about brain anatomy and function:
- Harvard University Medical School, The Whole Brain Atlas:
  http://www.med.harvard.edu/AANLIB/home.html

Resources for additional information about CT Scan technology:
- Radiology Info: http://www.radiologyinfo.org/en/info.cfm?pg=headct#part_eight

Resources for additional information on brain trauma:

References
- Harvard University Medical School, The Whole Brain Atlas:
  http://www.med.harvard.edu/AANLIB/home.html
VIII. Lesson Implementation

Opening of Lesson:
Open the lesson with a discussion about what students recall about brain injury from the Scene 1 lesson materials. Remind students that the case studies show that head injuries can cause different behavioral changes, depending on the severity and the areas of the brain affected.

- What is the underlying cause of the various behavioral changes that result from head injury?

Ask students to think about how the anatomy of the brain and the structures affected by injury interact to cause the functional symptoms of injury. This goal of this discussion is to encourage the students to begin thinking about brain anatomy and function.

- How might we study head injuries?
- What information might we need to know about the brain to understand how brain injury can lead to changes in behavior or function?
- Why are head injuries so serious?
- What happens when you get a head injury?
- How can we identify the neuroanatomical locations affected by head injuries? Explanation: One cannot simply take out the brain to examine an injury. There are some imaging techniques (CT, MRI, etc) that will be discussed in this lesson.
- Why is it important that we know the anatomy of the brain?

Before coming to class, as homework from the previous lesson, students should have completed an internet search about Phineas Gage and an associated student sheet. Start this lesson by discussing the information that students discovered during their search. Ask questions such as the following:

- What were some interesting things that you found about Gage?
- What actually happened to him?
- Which part of the brain did the rod go through?
- Although Gage did not immediately die, he did suffer some major changes to his life...
  - Which aspect of his life was affected the most?
  - What was his behavior like as a result?
- After your research on Gage, were you able to make any predictions for the functions of the frontal lobe? What were they?
- Do you think Gage would have encountered different lifestyle changes if the rod had gone through a different area in his brain? Why?

Through this discussion, students should begin to realize that there are different parts of the brain that are associated with different functions, and that the frontal lobe is important for personality, impulse control, social behavior, etc.
Teacher Pedagogical Content Knowledge

Additional details of the anatomy and the function of the brain at various anatomical planes (coronal, sagittal, axial section) and levels can be accessed by downloading the Brain Voyager Brain Tutor free software (http://www.brainvoyager.com/downloads/downloads.html). This application allows the viewer to navigate through a 3D human brain model. It is user-friendly and easy to navigate once familiar with the program.

Brain Voyager can be used as a part of the lesson as an interactive way for students to learn about brain anatomy and function. Because the program integrates the 3D and the 2D images of the human brain, it is a good way for students to make connections between a 3D brain and CT scan images. This software can be used to show students how brain structures look on a CT scan or an MRI by choosing the name of the structure from the drop-down menu and selecting the X, Y, Z plane.

This software can be downloaded to smart phones and tablet computers for free.

Main Part of Lesson:

Activity 1: How to read a CT scan

In this activity, students learn about a widely used imaging technique as a valuable diagnostic tool in medical settings. They learn how to read a normal CT scan and identify the basic structures of the brain.

To capture students’ interest in the activity, ask the following questions:

- Have you ever had an X-ray before? If so, which part of your body was X-rayed?
- Have you heard of MRI or CT scan? What do these words mean?
- Have you ever seen a CT scan or an MRI image? What do these look like?
- Have you seen an X-ray device, a CT scanner or an MRI device?
- What are these CT scans used for? Which structures of the body can be viewed using these tools?
- Have you seen these devices being used in popular medical TV shows (such as House M.D. or Grey’s Anatomy or other TV shows)? For what types of diseases or injuries do the TV doctors use these technologies?

Teacher Content Knowledge: Medical Technology

Medical imaging has a crucial role in diagnosis of diseases or disorders. Students may have familiarity with various medical imaging technologies such as X-rays, ultrasound, MRI or CT scans either by direct experience or by knowing someone who had a procedure using these technologies. Therefore, the use of medical imaging technology...
is relevant to their lives. This lesson provides a good opportunity to discuss the role of
technology in medicine and how imaging techniques differ from each other and the
relative strengths of each.

After capturing the students’ attention and interest in this activity, explain the use of
this technology in the medical settings. MRI and CT imaging are highly advanced
diagnostic tools that can be used to see the 3D view of the internal structures of the
body including the brain and other internal organs. One of the differences between a
MRI and a CT scan is that the MRI has higher resolution; with the CT scan, it is hard to
see the precise details of soft tissue. On the other hand, MRI is more expensive and
requires much longer time to produce the image. Thus, the CT scan is often very useful
in medical emergencies when time is a critical factor. Even though the CT scan emits
more radiation than a regular chest X-ray, the benefits may outweigh the risks.
Describe the strengths and weaknesses of each technology and ask students when
they would recommend using one technology over another. For example, would they
use a CT scan for dental work or braces? A head injury in a car accident?

For more information, refer to the following resources:

- http://www.radiologyinfo.org/en/info.cfm?pg=headct#part_eight

Following the discussion, tell students that they will learn some of the basics on how to read a CT scan in
today's lesson.

Give students the “How to Read a CT Scan” (GH_L2_StudentSheet_HowToReadCTscan) handout. Allow
them to read through the handout with a partner and discuss some of the information that may be new
to them or that they think is important. Then, go through the handout briefly with them to cover the
following main concepts:

- A Computer Tomography (or “CT”) Scan is a type of x-ray that is used to see the brain.

- Due to the way in which X-ray beams work, high density materials, such as the skull, appear
  very light on the CT scan and low density things, such as air or some tissues, appear dark on
  the CT scan.

- One of the main things to remember when looking at a CT scan is that, you are looking from
  the bottom of the brain towards the top. Therefore, the structures that you see on the right
  side of the CT image are actually in the LEFT hemisphere of the patient and vice versa. For
  example, in most people, Broca’s Area (the part of the brain responsible for certain
  elements of language production) is located in their left hemisphere—on which side would
  Broca’s Area appear on a CT scan?
As the CT scan moves from the bottom of the brain to the top, you are seeing slices of the brain (almost like slices of a loaf of bread).

After highlighting the main points to the students, tell them that they can refer back to this sheet while they do the computer activity that comes next.

For The Golden Hour computer activity, it would be best for students to work in partners or on their own so that everyone has an opportunity to interact with the game. Before beginning the game, remind the students what they have done previously in Scene 1 of the game. As the medical student, they are working on a medical emergency case in which a patient was brought into the hospital after a bike accident where he fell and suffered a head injury.

Hand out the CT Report student sheet. Today, students will play Scene 2 (CT Scan) of the game. The patient has just been brought into the hospital by the EMTs (Emergency Medical Technicians). Explain that, in this second scene of the game, students learn about CT scans and use their knowledge to identify the type of injury the patient has suffered.

To begin scene 2 of the game, when the menu screen appears, ask students to click on the “Scenes” button and then on “Scene 2.0 CT Scan”. An image of a woman will appear—this is the CT technician who will help the players through this scene of the game. The character will introduce herself in a dialogue box saying “Hi, my name’s Allana. I’m excited that you have the chance to help us with this patient! I hope you’ll do well and can be a part of our team.” From this point on, the students progress through the game by clicking the right pointing (next) arrow in each dialogue box or by clicking as directed by the dialogue. Also, at times, if a player does not respond within a certain amount of time, an object in the game will flash yellow, to further direct the player about what to do next.

Note: The Golden Hour game will continue to be updated. Therefore, some of the details provided here (i.e. quoted dialogue) may change. However, overall, the content covered in each section of the game will remain the same.

Allow students to play through Scene 2 (CT Scan) of the game.

In this scene of the game, students first briefly review how a CT scan works. Students then explore the anatomical landmarks of a healthy brain while comparing an illustrated brain with a CT scan image of the brain. Encourage students to take their time examining each landmark in both the CT scan and the illustrated image. They should carefully read the descriptions of each landmark’s function. They can also record this information about the brain structures and their functions in the margins of the CT Report student sheet or on a separate sheet of paper, so that they can refer back to it. They will review the following anatomical landmarks of the brain and their functions:

- Frontal Lobe
- Temporal Lobe
- Occipital Lobe
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- Skull
- Cerebellum
- Lateral Ventricle
- Thalamus

As the students review the landmarks, ask them to compare how the structures look on a CT scan vs. the illustration of the brain.

After students review the anatomical landmarks of the brain, the game takes them through a short quiz where they identify the parts they just learned on a CT scan image.

By the end of the CT scan Quiz, students should be fairly familiar with how the structures look on a CT scan. Have the students pause playing after this quiz to have a discussion about the following questions before moving on to the next section on brain injury types:

- In what way are CT scans important for patients with TBI?
- Have you ever seen the X-ray image of a broken limb? Is it clear to identify the damage on the X-ray image?
- What do you think the CT scan of a patient with a brain injury might look like?
- Why do you think it is important to know the brain’s anatomy and function when diagnosing a brain injury?
- Do you think the location of the injury in the brain would be a factor in how severe the injury is? Why?

**Activity 2: How to read an abnormal CT scan**

This activity will simulate the medical setting, giving students a chance to see the effect of a trauma in the brain at a macroscopic level. Students look at a number of TBI CT scans and identify the affected structures and interpret the functional impact of the injury.

Hand out the “How to Read an Abnormal CT Scan” *(GH_L2_StudentSheet_HowToReadAnAbnormalCTscan)* to them. This is a brief guide to learn about different types of TBIs and how to identify them on CT scans.

Ask students to work in their partners or groups to look through this handout to familiarize themselves with the four TBI types and how they appear on a CT scan. They will need to use this guide to complete the “TBI Case Puzzle”.

Hand out the “TBI Case Puzzle” *(GH_L2_StudentSheet_TBICasePuzzle)* to the students. In this puzzle, students are given 4 different patients and their CT scan images of different types of brain injury. For each patient case, the students need to: 1) decide which brain injury type they have, 2) Select whether the injury is in the patient’s left or right hemisphere, 3) identify the areas of the brain affected by the injury, and 4) based on the location, describe what functions of the patient may be affected/impaired.
As they do this activity, encourage them to refer to the *How to Read an Abnormal CT Scan* handout and use their knowledge of neuroanatomy and physiology as they read the patient’s CT scans.

When the students complete this activity, bring the class together to share and discuss responses. Begin the discussion by first asking which brain injury type each patient was diagnosed with. This will help to make sure all students are on the same page for the remainder of the discussion. While answers to the first 3 sections of each report should be the same for everyone, responses to the last two questions will likely vary slightly from group to group. In some cases there are multiple possible correct answers to brain areas and cognitive functions affected by injury. This is a good opportunity to remind the students that although certain areas of the brain are specialized for certain functions, all brain areas are very closely interconnected and lines between areas are not as rigid as they might appear in the illustrations. The following are some questions that should be considered for each case.

- What is the location of injury in each case?
- What signs did you use to figure out which injury each CT scan was showing?
- Predict which patient might have a speech disorder following TBI.
- Predict which patient might experience partial/temporary or permanent visual loss following TBI.
- Predict which patient might have severe memory problems.
- Predict which patient might have moderate to severe paralysis on the right side of his body.
- Predict which patient’s prognosis for recovery is lowest.

**Teacher Pedagogical Content Knowledge**

All of these questions about the location of injury, affected brain areas, and possible functional outcomes require the students to draw on knowledge they have been developing throughout the lesson. The questions on location of injury are fairly straightforward but the later questions, which ask for affected areas and possible outcomes, require students to synthesize some of the material they have learned. Therefore, if preferred, student responses to the last two questions can be written and collected for use as a formative assessment of their understanding of the material thus far. Another option is to assign the entire TBI Case Puzzle worksheet as an in-class assessment.

Tell students that now that they have learned about different types of brain injuries and how to read CT scans, they are ready to assess what type of TBI their patient in The Golden Hour game has suffered. Ask students to now continue playing the game. Through the game, the students review the four kinds of brain injuries: 1) open or penetrating head injury; 2) epidural hematoma, 3) subdural hematoma, and 4) diffuse axonal brain injury. After viewing these brain injuries, the students will come to a dialogue box that states, “Now that you are familiar with the CT imaging system, let’s take a look at the patient’s
scans.” Students then identify the patient’s injury as it appears on the CT scan and decide which type of TBI it is. As students play through the game, remind them to continue recording their findings on their CT Report student sheet.

Finally, at the end of the scene, students are prompted to complete a CT Scan Report of their findings. They are then led through a dialogue with the lead physician in charge of this case (Dr. Picotte) where they will need to decide the most appropriate next step and support their decision. This dialogue is designed within the claim, evidence, reasoning (CER) framework and encourages students to think critically about the information they have gathered. Through the dialogue and multiple-choice questions, students are guided to select their claim, evidence, and reasoning for recommending next steps. At the end of the dialogue, students are prompted to write their recommendation in paragraph form. In this paragraph, encourage students to write the recommendation for what the next step should be (their claim), add the evidence they collected that supports that claim, and provide the reasoning that explains how the evidence supports the claim.

As students complete the report and answer questions in the CER-style dialogue, remind students that they can pull up the tablet (by clicking on the tablet icon in the lower right corner of the game window) for help. The tablet records the information they have collected thus far in the game and makes it available for the students’ reference. They can also use their student sheets for help.

Students can use the back of the “CT Report” student sheet to construct their recommendation. They can first use the C, E, and R, columns to organize their thoughts about the three different components of a scientific explanation. Then, at the bottom of the page, in the “Medical Recommendation” section, they should synthesize these ideas into a coherent explanation written in paragraph form. As students work, scaffold them to write their recommendation for what the next step should be (their claim), add evidence they collected that supports that claim, and provide reasoning that explains how the evidence supports the claim.

If students chose to type their recommendation within the space provided in the game, they can either take a screen shot or copy-paste the paragraph into a word document in order to print it. If a printer is not available, students can copy their recommendation paragraph onto the back of the CT Report student sheet.

**IMPORTANT:** Medical recommendation responses submitted within the game will not be saved once students exit the game. Students should have their medical recommendation written on their student sheet or copied into a word document on the computer before exiting the scene.

This explanation completed by the students in a CER-style format can be collected and evaluated as an assessment of what they have learned thus far in the game.

The following is one example of what a recommendation summary (CER explanation) for the CT Scan scene of the game may look like.
**Example Recommendation Summary**

I recommend that the patient receives emergency surgery. Analysis of the CT scans of the patient's head show a gray, crescent-shaped appearance just under the skull on five adjacent scans. This indicates that there is a subdural hematoma on the right side of the head near the temporal lobe. Surgery should be performed because if the blood remains or continues to collect in the head, the hematoma will increase pressure within the skull and cause additional brain damage.

**Scientific Practices: Constructing explanations and engaging in argument from evidence**

Scientists must constantly exercise the ability to defend their claims, incorporate evidence, and work with peers to develop the best explanations of scientific phenomena. An important goal of science teaching is to encourage students to use their understanding of the science and the evidence available to them to construct logical and coherent explanations.

At the end of each segment of the game, students are asked to answer the question “What should be done next for the patient?” by providing a claim, evidence, and reasoning (CER). If students have not yet learned about the CER framework (McNeill & Krajcik, 2012) for constructing scientific explanations, instruct them in this approach before they complete their report for The Golden Hour game. Explain to students that all good scientific explanations must have these three components. For any scientific explanation, you must first make a sound claim, provide evidence that supports that claim, and explain the reasoning that connects the evidence to the claim. Encourage students to think explicitly about these three components and why each one is an important part of a sound scientific explanation.

In The Golden Hour game, students are given the opportunity and appropriate scaffolds to practice these important skills. Situated in the format of a conversation with the lead physician at the end of each segment, students are guided to make and defend a claim based on the evidence and knowledge they have accumulated. The claim, evidence, and reasoning framework used to develop this scene supports students and further structures the process as they practice constructing scientific explanations and engaging in argument from evidence.

**Conclusion of Lesson:**

After students finish the CT Assessment in The Golden Hour game, review some of the main ideas from this lesson. Facilitate a discussion to help them review and to think about these concepts by asking questions such as the following:

- How much and what kind of information can doctors gather by looking at CT scans?
- To what extent do you think the CT scans can help predict functional outcomes?
• What are the four different traumatic brain injury types you learned about?
• What type of injury did the patient in The Golden Hour have?
• Where was his injury located and how does this information help to predict possible impairments resulting from the injury?

Assessment
There are several ways in which learning can be assessed for this lesson. The first is to collect the “TBI Case Puzzle” document where the students were asked to identify brain injury types and explain possible effects of the injury. Also, if preferred, the “TBI Case Puzzle” worksheet can be used instead as an in-class assessment. Another assessment opportunity for this lesson is the recommendation summary (CER explanation) in which students use evidence from the scene they just completed to make a claim regarding next steps in the medical procedure.